Association of physical fitness and motor ability at young age with locomotive syndrome risk in middle-aged and older men: J-Fit+ Study

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Abstract

Background Physical fitness and motor ability are associated with the incidence of locomotive syndrome (LS) in the elderly. The relationship between physical fitness and motor ability at a young age and LS risk in later life remains to be clarified. This study examined the association between physical fitness and motor ability among university students and their risk of LS in middle and old age. Methods The participants were 231 male alumni aged 48–65 years of the Department of Physical Education of a university in Japan. Physical fitness and motor ability test results during their fourth year of university were used. Physical fitness tests included side-step test, vertical jump tests, back muscle, grip strength, trunk lift, standing trunk flexion, and step-test. Motor ability was tested using the 50-meter, 1,500-meter run, running long jump, hand-ball throw, and pull-up test. LS risk was assessed using a seven-question standardized self-administered Loco-check questionnaire. Participants were divided into three groups (low, medium, and high) based on physical fitness and motor ability test results at young age and the LS risk was assessed at older age across the three groups using the Cox proportional hazards models. Results From the 2017 follow-up questionnaires, LS risk was suspected in 31 (13.4%) participants. Higher performance on the side-step test was associated with reduced risk of LS (hazard ratio 0.22; 95% confidence interval, 0.058–0.798, P=0.022). Conclusions Good agility (side-step test) at a young age may reduce future risk of LS among middle-aged and older men.

Background

Locomotive syndrome (LS), a condition proposed by the Japanese Orthopaedic Association in 2007, is observed in high-risk individuals with musculoskeletal disease that will likely require nursing care at some point [1, 2]. The number of individuals who are at risk for developing LS after the age of 40 years in Japan is predicted to be 47 million [3]. However, LS is not just a disease of middle-aged people and elderly; the incidence of LS among men under the age of 40 is approximately 13% [4]. In addition, about 22.3% of men need nursing care due to LS related fractures, falls, and/or musculoskeletal disorders, according to the 2016 Comprehensive Survey of Living Conditions conducted by the Ministry of Health, Labour and Welfare in Japan [5]. Therefore, in order to prevent nursing care need for the elderly in the future, prevention of LS is necessary from a young age.

LS has been recognized as an important risk factor for falls [6] and reduced mobility in activities of daily living (ADL) [7, 8]. Moreover, LS has also been reported to be associated with increased nursing care in the elderly in the future [9]; thus, it is necessary to reduce the occurrence of LS. Recently, research on the relationship between physical fitness in the elderly and LS has been actively conducted to prevent LS. There have been many study findings indicating that in the elderly the risk of LS is associated with static balance [10] and with the back-and-forth postural sway in the balance test [11], timed-up-and-go test [12], walking ability [10], mobility [7], grip strength [13], and back muscle strength [14]. However, it has not been clarified what kind of physical fitness and motor ability at young age is associated with LS, and whether increasing physical fitness and motor ability at a young age leads to prevention of LS in older adults.

We hypothesized that good physical fitness and motor ability at a young age might reduce the risk of LS in older age. Thus, clarifying the influence of physical fitness and motor abilities in younger individuals on the risk of LS in older age may contribute to early LS risk prevention. To the best of our knowledge this is the first study to investigate the association between physical fitness, motor ability at young age in a cohort of 4-year university students and the risk of LS in older age Japanese men who graduated from university alumni in Japan.

Methods

Study design and population

This study is a historical cohort study. Our study included male alumni who graduated from the Department of Physical Education of a university in Japan. The anthropometric, physical fitness tests and motor ability tests are implemented once per year at the university over the four years of university studies. The J-Fit Study is a project that uses the accumulated 50 years of data collected as indicated above for research into the association between physical fitness, motor ability at a young age and future diseases, such as diabetes, type 2 diabetes, and hypertension [15-18]. In the present study, we used data obtained from tests results of subjects in their fourth year at university.

Participants eligible for the present study were 3918 male alumni who graduated between 1956 and 1991. This study did not include female alumni because the Department of Physical Education of the university did not enroll female students until 1991. After excluding 382 participants who had died or had an unknown address, a total of 3536 participants were sent the self-administered questionnaire about their medical background from 2007–2009 and in 2011. Of the 3536 participants, 1385 alumni completed and returned questionnaire at least once [17]. In March 2017, another follow-up survey was conducted, involving these 1385 alumni. The alumni received a self-administered questionnaire to obtain information on age, height, weight, body mass index (BMI), daily step counts, and locomotive organs (Loco-check). Individuals (n = 702) who did not return the questionnaire were excluded. Furthermore, individuals who graduated before 1973 were also excluded (n = 321, because before 1973, our university did not perform physical fitness tests and motor ability tests, and these data were unavailable). In addition, individuals who had no information on physical fitness and motor ability in the fourth year of university were excluded (n = 131). Finally, 231 individuals aged 48–65 years were eligible for the analysis. The selection of participants for this study is shown in Fig. 1.

Insert Fig. 1. here

Physical fitness and motor ability tests

The physical fitness tests consisted of the following 7 tests: agility was measured using the side-step test, power was measured using the vertical jump test, muscular strength was measured by back muscle strength and grip strength, flexibility was measured using trunk lift and standing trunk flexion, and endurance was measured using the step-test. The motor ability tests consisted of the following five tests: 50-meter run, 1500-meter run, running long jump, hand-ball throw, and pull-up. Physical fitness tests and motor ability tests were performed as described in a previous study [19, 20], and an additional file shows this in more detail [see Additional file 1]. In addition, in order to calculate a comprehensive score that reflected the comprehensive physical fitness level and motor ability level, we converted scores according to a scoring table for each test. In the present study, the comprehensive scores of the physical fitness level and the motor ability level were used as two parameters for analysis.

Locomotive syndrome risk test

Seven questions were prepared for participants in the Loco-check questionnaire by the Japanese Orthopaedic Association (JOA) to evaluate locomotive organs. This questionnaire is simple and easy to understand even for elderly people [21], detailed contents for investigation consisted of the following questions: “1. You can't put on your sock standing on one leg”, “2. You often trip or slip around the house”, “3. You need to hold on to the handrail when climbing the stairs”, “4. You have difficulty doing moderately heavy housework”, “5. You have difficulty carrying home 2 kg of shopping (e.g., equivalent to two 1-L cartons of milk)”, “6. You can't walk for a quarter of an hour nonstop”, and “7. You can't make it across the road before the light turns red” [22]. Subjects answered the Loco-check questions with either a ‘yes’ or ‘no’.” In this study, if the subjects answered ‘yes’ to one or more items on the “Loco-check”, they were defined as subjects suspected of LS risk (hereafter referred to as the LS risk group). If they answered “no” to all seven items, they were defined as No LS risk subjects (hereafter referred to as the NLS risk group) [22].

Statistical analysis

First, we compared differences in participants’ characteristic between the NLS group and LS risk group used the independent samples T-test for continuous variables and the chi-squared test for categorical variables.

Next, to identify important factors related to LS risk, physical fitness and motor ability variables were compared between the NLS and LS risk groups using independent samples T-test, and analysis of covariance (ANCOVA). ANCOVA was adjusted for age at the follow-up questionnaire, which is a known factor associated with LS [11, 23]. To identify potential factors correlated with LS risk among the physical fitness variables and those that showed differences in motor ability (P value < 0.20) [11] the ANCOVA analyses was adjusted for age, using the aforementioned variables for the subsequent analysis.

Finally, we divided the participants into tertiles (low, medium, and high) based on physical fitness and motor ability variables during university age and compared LS risk across the three groups using Cox proportional hazards models. We obtained both crude and adjusted hazard ratios (HR) with their 95% confidence intervals (CI) for the risk of LS. This analysis was adjusted for the following factors: age, weight, BMI at the time of follow-up, and adolescent physical fitness and motor ability levels at the time of university. All analyses were conducted using SPSS Statistics for Windows, Version 21.0 (SPSS Inc., Chicago, IL, USA). A P value < 0.05 was considered significant.

Results

Table 1 shows the basal characteristics of participants in the NLS and LS risk groups. The median age of the participants at the follow-up questionnaire was 58 years (interquartile range, 54–62). The median follow-up period was 37 years (interquartile range, 33–41). During the follow-up period from May 1973 through March 2017, LS risk was suspected in 31 (13.4%) participants. In participants of the LS risk group, weight, and BMI at the follow-up questionnaire were significantly higher than in the participants in the NLS group (P < 0.05).

Insert Table 1 here

Table 2 shows the differences between the NLS group and the LS risk group in physical fitness tests and motor ability tests. The side-step test, standing trunk flexion, and hand-ball throw tests showed differences between the NLS and LS risk groups ($P < 0.2$), whereas physical fitness scores and motor ability scores were not different. Furthermore, after controlling for age, the side-step test also showed a difference between the two groups ($P < 0.2$).

Insert Table 2 here

Because the side-step test was confirmed as an important factor related to LS risk, a Cox proportional hazards model analysis for the variable was performed (Table 3). In an unadjusted analysis, the side-step test (agility) was not significantly associated with the risk of LS (Model 1). After adjusting for age (continuous variable) at university, the side-step test (agility) also remained not significantly associated with the risk of LS (Model 2). In another model, age tertiles (low, medium, high), weight tertiles (low, medium, high), BMI tertiles (low, medium, high) at the follow-up questionnaire were entered as adjusted factors instead of the age (continuous variable) at university (Model 3). In Model 3, the risk of LS was significantly lower in participants with high side-step test results (agility) than in participants with low side-step test (agility) (HR 0.24; 95% CI, 0.075–0.792, $P = 0.019$). In Model 4, which included Model 3 plus the results of physical fitness tests, motor ability test tertiles (low, medium, high) and daily step counts (steps/day) were entered as adjusted factors. The high side-step test (agility) participants had a significantly lower risk of LS than low side-step test (agility) participants (HR 0.22; 95% CI, 0.058–0.794, $P = 0.022$).

Insert Table 3 here

Tables 4 and 5 show hazard ratios of the risk of LS according to the physical fitness level and the motor ability level. No significant associations with the risk of LS were found.

Insert Table 4 and Table 5 here

Discussion

This study examined the association of physical fitness and motor ability of university-aged students with the risk of LS in middle-aged and older Japanese men. The results showed that risk of LS was lower in high side-step test (agility) participants than in low side-step test (agility) participants at a young age. The results of this study demonstrate the good agility at a young age contributes to a lower risk of LS at middle and old age.

Agility has been identified as the ability to include whole-body change of direction as well as change of limb direction [24, 25], the ability to coordinating quickly and accurately the big muscles of the body in a particular activity (a neurological function) [26]. This definition suggests that ability involves modulable movements and physical reactions. If agility is a concept of harmony, then it can also be considered as physical control, with muscle control being an integral part of agility. Because the side-step test includes the concepts mentioned above, this test is an accepted way to measure agility in Japan, and is also considered an effective indicator. In LS, the three main components of the locomotive system are the bones (support), joints and intervertebral discs (mobility, shock absorption), and the muscle and nervous system (drive, control) [27]. Therefore LS is identified as a condition in which mobility functions such as sit-to-stand or gait, are reduced as a result of locomotive organ/system impairment [1]. Although agility and LS are originally two completely different concepts, we can also see that agility has many determinants that are common to LS. For example, the whole-body change of direction as well as change of limbs in the concept of agility is actually dependent on the support of bones and the help of joints. In addition, modulation of movements (a neurological function) in the concept of agility and the nervous system in the concept of LS refer to the individual's ability to control the body and muscles. Hence agility may be a predictor of the risk of LS.

Furthermore our results support past findings with respect to the association between physical fitness and LS risk in the elderly. Yoshimura et al. found that slower Five Times Sit to Stand Test times (lower extremity strength) were associated with a higher stage of LS in middle-aged and older individuals [7]. Negrete and Brophy reported that the single-leg isokinetic squat strength (lower extremity strength) was associated with complex multi-directional tasks over short distances (agility) in university-aged subjects [28]. In addition, Pembrey et al. concluded in their study that agility, and jumping ability (lower extremity strength) could assess the same physical attributes in young competitive-level team sports players [29]. These authors showed that lower extremity strength played an important role in agility among university-aged subjects. We believe that although the relationship between the lower limb strength of young people and the lower limb strength of elderly people is equivocal, both may be positively correlated. Therefore, based on these findings, agility at a young age may be a sensitive factor for predicting the risk of LS, and may indirectly help prevent the progression of LS.

However, this association was not confirmed in Model 1. This is because LS risk includes several important factors, including age, which were not considered in Model 1. Age is considered to be an important factor in LS risk [11, 23]. Nevertheless, agility was still not associated as risk of LS when young age was considered in Model 2. This is because, among the 231 participants, 205 (88.7%) were aged 21 years, 23 (10.0%) were aged 22 years, and three (1.3%) were aged 23 years at the fourth year of university. This result (Model 2) suggested that this difference did not introduce confounding effects. Therefore, in Model 3 we identified a negative relationship in terms of agility and the risk of LS when age, weight, and the BMI at the follow-up questionnaire were considered. The reasons for considering weight and BMI in Model 3 is that weight and BMI reported in the follow-up questionnaire were significantly higher than those of the participants in the NLS group. It is also important to take the results of physical fitness tests, motor ability tests, and daily step counts into consideration. Looking at the significant estimate, it is not stronger in Model 4 than in Model 3. This suggests that our results are not due to confounding effects from daily step counts and the results of physical fitness tests, motor ability tests except for the side-step test.

We did not find any relationship between the vertical jump test (power) or the step-test (endurance) and the risk of LS. Although the vertical jump test also shares characteristics in common with lower extremity strength, the vertical jump test does not only measure lower extremity strength, it also depends on speed (instantaneous power) [30, 31]. The step-tests assesses the ability to perform a specific muscular action for a prolonged period of time, and not just a bout of lower extremity strength [31]. Meanwhile, the LS is identified as a condition in which mobility functions such as sit-to-stand or gait are reduced as a result of locomotive organ/system impairment [1]. It is noteworthy that the Loco-check questionnaire did not comprise items of instantaneous power and endurance; thus, the vertical jump test and the step-test might not be factors predictive of the risk of LS.

In this study, back muscle strength and grip strength did not show any association with the risk of LS. The most plausible reason for this finding was that seven questions on the Loco-check questionnaire evaluated the lower-extremity physical function status in middle-aged and elderly people, and there was no question related to back muscle strength or grip strength, therefore back muscle strength and grip strength were not associated with the risk of LS.

Conversely, there was no significant relationship found between trunk lift (flexibility), standing trunk flexion (flexibility), and the risk of LS. Consistent with our results, no significant relationship between functional reach (flexibility) [32] and the risk of LS has been reported in Japanese individuals aged 40–91 years[13]. This result suggested that there is no association between flexibility and the risk of LS.

Physical fitness is defined as the ability to carry out daily tasks with vigor and alertness without undue fatigue and with ample energy to enjoy leisure-time pursuits and respond to emergencies[33]. Moreover, basic physical fitness elements include muscular strength, muscular endurance, and circulatory endurance. Muscular power, agility, speed, and flexibility contribute to motor ability; thus, kinesthetic arm-eye foot-eye coordination is needed for general motor ability [24]. Thus, we may consider that physical fitness reflects ADL, and motor ability is higher than physical function. In this study, none of the motor ability measurement items were associated with the risk of LS. Although the reason for these results is unclear: the seven questions on the Loco-check questionnaire designed to evaluate ADL and motor ability may not have been able to directly evaluate the ADL.

Our study has several limitations. First, the current findings were not representative of all Japanese men because the study population was predominantly composed of middle-aged and older men from a single department in one university, and almost all were former university athletes. Second, only male alumni were included in this study. Therefore, the relationship between physical fitness, motor ability at young age and LS risk of middle-aged and older women was not addressed. Third, a self-selection bias was possible because the medical background and LS risk test was examined using a self-administered questionnaire. Finally, although we considered several potential confounding factors, we did not rule out the influence of current physical fitness and motor ability. However, we considered the influence of daily step counts. However, despite these limitations, the current findings are the first to confirm the influence of physical fitness and motor ability at a young age on the progression of LS risk over a long follow-up period. The present results may support our hypothesis that good agility (side-step test) at a young age may reduce future risk of LS in older age. Given our results, we believe that good agility at a young age is necessary in order to inhibit the progression of LS risk. In addition, our results present important clinical implications and should be taken into consideration when developing LS prevention exercise programs for young people.

Conclusions

The present study demonstrated that, good agility (side-step test) at a young age may reduce future risk of LS among Japanese middle-aged and older men.

Abbreviations

ADL: activities of daily living; ANCOVA: analysis of covariance; BMI: body mass index; CI: Confidence interval; HR: hazard ratios; JOA: Japanese Orthopaedic Association; LS: locomotive syndrome; NLS: no locomotive syndrome

Declarations

Ethics approval and consent to participate

This study was conducted with the approval of the Ethics Committee of Juntendo University (authorization code: 31-25). All participants provided informed consent for data collection and storage.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

SS and KS conducted the analyses and drafted the initial manuscript; HN conceptualized and oversaw the study, reviewed and revised the manuscript; KS, YK, NF, YS, and HN gave advice on methodology, and critically reviewed and revised the manuscript for important intellectual content. All authors contributed to writing, reviewing or revising the paper and read and approved the final manuscript. KS is the guarantor of this work and had full access to all the data in the study and takes responsibility for its integrity and the accuracy of the data analysis.

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Supplementary Information

Additional file 1. Description of the instructions provided to participants for the execution of physical fitness tests and motor ability tests and instructions on how results were to be recorded.

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Tables

Table 1 Characteristics of participants

	All (n = 231)		NLS risk group (n = 200)		LS risk group (n = 31)		*P*-value[c]
Age[a], years	58.0	(54.0, 62.0)	58.0	(54.0, 62.0)	59.0	(53.0, 64.0)	0.332
Height[a], cm	172.0	(168.0, 177.0)	172.3	(168.5, 177.1)	172.0	(167.0, 176.0)	0.888
Weight[a], kg	71.0	(65.0, 78.0)	70.5	(65.0, 77.0)	72.0	(68.0, 80.0)	0.048
BMI[a], kg/m^2	23.8	(22.1, 25.5)	23.7	(22.0, 25.4)	24.4	(23.3, 26.5)	0.020
Daily step counts[a], steps/day	5000.0	(0.0, 8000.0)	4000.0	(0.0, 8000.0)	5000.0	(1500.0, 6000.0)	0.939
Smoking status[a], n (%)							
Never smoker	94	(40.7)	86	(43.0)	8	(25.8)	0.070
Current smoker	37	(16.0)	29	(14.5)	8	(25.8)	0.110
Former smoker	100	(43.3)	85	(42.5)	15	(48.4)	0.538
Drinking status[a], n (%)							
None	23	(10.0)	22	(11.0)	1	(3.2)	0.329
Current	194	(84.0)	166	(83.0)	28	(90.3)	0.431
Former	14	(6.0)	12	(6.0)	2	(6.5)	1.000
Follow-up period[a], years	37.0	(33.0, 41.0)	36.5	(33.0, 41.0)	38.0	(32.0, 43.0)	0.355
Age[b], years	21.0	(21.0, 21.0)	21.0	(21.0, 21.0)	21.0	(21.0, 21.0)	0.564
Height[b], cm	172.8	(168.8, 177.8)	172.8	(168.8, 177.8)	173.3	(168.4, 176.7)	0.864
Weight[b], kg	65.5	(61.5, 71.0)	65.5	(61.5, 71.0)	66.4	(61.5, 72.5)	0.740
BMI[b], kg/m^2	22.0	(21.0, 23.2)	22.0	(21.0, 23.2)	22.2	(21.3, 23.5)	0.801
Year of graduation[b]	1981	(1977, 1985)	1981	(1977, 1985)	1980	(1975, 1986)	

The data are presented as medians (interquartile range) for continuous variables and number (percentage) for categorical variables.

BMI, body mass index, calculated as weight in kilograms divided by height in meters squared; LS, locomotive syndrome; NLS risk group, answered "no" to all seven items on "Loco-check"; LS risk group, "yes" to one or more items on "Loco-check."

[a] All items were the date at follow-up questionnaire. [b] All items were the date in the fourth year at university. [c] *P*-value of independent-samples *t*-test (for continuous variables) or Chi-squared test (for categorical variables) is between NLS risk group and LS risk group.

Table 2 Comparison between the NLS group and LS risk group on physical fitness tests and motor ability tests

	All (n = 231)		NLS risk group (n = 200)		LS risk group (n = 31)		*t*-test *P*-value[a]	ANCOVA *P*-value[b]
Physical fitness tests								
Side-step test, point	51.19	(4.2)	51.37	(4.3)	50.10	(3.2)	0.114	0.133
Vertical jump test, cm	63.84	(6.6)	63.71	(6.7)	64.74	(6.1)	0.420	0.337
Back muscle strength, kg	171.96	(30.2)	171.69	(30.2)	173.71	(30.5)	0.729	0.520
Grip strength, kg	51.42	(6.3)	51.34	(6.1)	51.97	(7.1)	0.604	0.617
Trunk lift, cm	59.22	(7.2)	59.11	(6.9)	59.97	(9.2)	0.538	0.713
Standing trunk flexion, cm	14.61	(5.6)	14.42	(5.6)	15.90	(5.8)	0.171	0.211
Step-test[c]	73.37	(14.4)	73.83	(14.0)	70.43	(16.4)	0.222	0.250
Physical fitness scores, point	28.13	(2.1)	28.13	(2.1)	28.13	(1.9)	0.992	0.900
Motor ability tests								
50-m run, s	7.07	(0.3)	7.07	(0.3)	7.03	(0.3)	0.534	0.434
1,500-m run, s	331.37	(31.8)	331.45	(32.4)	330.90	(28.5)	0.930	0.839
Running long jump, cm	528.99	(43.5)	528.88	(43.4)	529.71	(44.3)	0.921	0.795
Hand-ball throw, m	31.45	(4.1)	31.31	(4.0)	32.32	(4.5)	0.199	0.211
Pull-up, point	14.33	(5.4)	14.37	(5.5)	14.10	(4.7)	0.795	0.826
Motor ability scores, point	63.90	(12.2)	63.74	(12.2)	64.97	(12.4)	0.602	0.505

The data are presented as the mean value (standard deviation).

NLS, answered "no" to all seven items on "Loco-check"; LS, locomotive syndrome; LS, "yes" to one or more items on "Loco-check".

ANCOVA: analysis of covariance.

[a] *P* value of independent-samples *t*-test. [b]Age-adjusted at follow-up questionnaire. [c] Step-test is scored by the index derived from the formula shown in the eMaterials.

Table 3 Hazard ratios of the risk of locomotive syndrome according to Side-step test (agility) fitness level

	All	Diagnosed locomotive syndrome	Unadjusted model (Model 1)		Adjusted model (Model 2)		(Model 3)		(Model 4)	
		n (%)	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Side-step test, point (agility)		31 (13.4%)								
Low ≤ 50	90	18 (20.0%)	1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)	
51 ≤ Medium ≤ 53	80	9 (11.3%)	0.71 (0.315–1.591)	0.403	0.66 (0.289–1.502)	0.321	0.49 (0.203–1.161)	0.104	0.44 (0.159–1.222)	0.115
High ≥ 54	61	4 (6.6%)	0.45 (0.151–1.337)	0.150	0.43 (0.142–1.272)	0.126	0.24 (0.075–0.792)	0.019	0.22 (0.058–0.798)	0.022

HR, hazard ratios; CI, confidence interval. The data are presented as the hazard ratio (95% confidence interval [CI]).

Model 1 was the unadjusted model.

Model 2 included Model 1 plus age (continuous variable) at university was adjusted as covariates.

Model 3 included Model 1 plus age (low, medium, high), weight (low, medium, high), and body mass index (low, medium, high) at the follow-up questionnaire were entered as adjusted factors.

Model 4 included Model 3 plus the results of physical fitness tests, motor ability tests (low, medium, high), and daily step counts, steps/day, were entered as adjusted factors, except the side-step test.

Table 4 Hazard ratios of the risk of locomotive syndrome according to physical fitness level, except the side-step test

	All	Diagnosed locomotive syndrome n (%)	Adjusted model HR (95% CI)	*P* value
Physical fitness tests				
Vertical jump test, cm		31 (13.4%)		
Low ≤ 61	81	8 (9.9%)	1.00 (Reference)	
62 ≤ Medium ≤ 67	83	13 (15.7%)	1.79 (0.498−6.447)	0.372
High ≥ 68	67	10 (14.9%)	1.75 (0.455−6.695)	0.416
Back muscle strength, kg		31 (13.4%)		
Low ≤ 158	77	9 (11.7%)	1.00 (Reference)	
159 ≤ Medium ≤ 181	79	12 (15.2%)	1.45 (0.452−4.636)	0.533
High ≥ 182	75	10 (13.3%)	1.46 (0.376−5.632)	0.587
Grip strength, kg		31 (13.4%)		
Low ≤ 49	86	12 (14.0%)	1.00 (Reference)	
50 ≤ Medium ≤ 53	68	7 (10.3%)	0.57 (0.161−1.992)	0.376
High ≥ 54	77	12 (15.6%)	0.51 (0.147−1.734)	0.278
Trunk lift, cm		31 (13.4%)		
Low ≤ 56	79	12 (15.2%)	1.00 (Reference)	
57 ≤ Medium ≤ 62	81	6 (7.4%)	0.45 (0.143−1.425)	0.175
High ≥ 63	71	13 (18.3%)	1.36 (0.438−4.204)	0.596
Standing trunk flexion, cm		31 (13.4%)		
Low ≤ 12	88	10 (11.4%)	1.00 (Reference)	
13 ≤ Medium ≤ 17	74	9 (12.2%)	0.86 (0.298−2.460)	0.774
High ≥ 18	69	12 (17.4%)	1.00 (0.327−3.078)	0.996
Step-test[a]		31 (13.4%)		
Low ≤ 65	77	13 (16.9%)	1.00 (Reference)	
66 ≤ Medium ≤ 80	79	10 (12.7%)	0.91 (0.327−2.517)	0.851
High ≥ 81	75	8 (10.7%)	0.73 (0.216−2.450)	0.608
Physical fitness scores, point		31 (13.4%)		
Low ≤ 27	85	10 (11.8%)	1.00 (Reference)	
28 ≤ Medium ≤ 29	87	13 (14.9%)	1.10 (0.331−3.638)	0.878
High ≥ 30	59	8 (13.6%)	1.16 (0.247−5.481)	0.849

HR, hazard ratio; CI, confidence interval. The data are presented as the hazard ratio (95% confidence interval [CI]). In adjusted model the results of physical fitness tests and motor ability tests (low, medium, high), age (low, medium, high), weight (low, medium, high), body mass index (low, medium, high) and daily step counts, steps/day, at follow-up questionnaire were entered as adjusted factors.

[a] Step-test was scored by the index derived from the formula shown in the eMaterials.

Table 5 Hazard ratios of the risk of locomotive syndrome according to motor ability level

		Diagnosed locomotive syndrome	Adjusted model	
	All	n (%)	HR (95% CI)	*P* value
Motor ability tests				
50-m run, s		31 (13.4%)		
Low ≤ 6.9	89	11 (12.4%)	1.00 (Reference)	
7.0 ≤ Medium ≤ 7.2	77	15 (19.5%)	1.31 (0.462−3.726)	0.611
High ≥ 7.3	65	5 (7.7%)	0.33 (0.069−1.599)	0.169
1,500-m run, s		31 (13.4%)		
Low ≤ 318	79	13 (16.5%)	1.00 (Reference)	
319 ≤ Medium ≤ 342	75	9 (12.0%)	0.56 (0.193−1.649)	0.296
High ≥ 343	77	9 (11.7%)	0.58 (0.133−2.496)	0.462
Running long jump, cm		31 (13.4%)		
Low ≤ 514	79	11 (13.9%)	1.00 (Reference)	
515 ≤ Medium ≤ 545	78	11 (14.1%)	1.07 (0.297−3.855)	0.917
High ≥ 546	74	9 (12.2%)	0.86 (0.216−3.441)	0.834
Hand-ball throw, m		31 (13.4%)		
Low ≤ 30	94	10 (10.6%)	1.00 (Reference)	
31 ≤ Medium ≤ 33	73	8 (11.0%)	0.93 (0.273−3.142)	0.903
High ≥ 34	64	13 (20.3%)	0.68 (0.181−2.562)	0.569
Pull-up, point		31 (13.4%)		
Low ≤ 11	82	9 (11.0%)	1.00 (Reference)	
12 ≤ Medium ≤ 17	82	15 (18.3%)	1.73 (0.558−5.366)	0.342
High ≥ 18	67	7 (10.4%)	1.43 (0.344−5.936)	0.623
Motor ability scores, point		31 (13.4%)		
Low ≤ 58	80	9 (11.3%)	1.00 (Reference)	
59 ≤ Medium ≤ 70	80	10 (12.5%)	0.42 (0.088−1.998)	0.276
High ≥ 71	71	12 (16.9%)	0.51 (0.052−4.904)	0.556

HR, hazard ratios; CI, confidence interval.

The data are presented as the hazard ratio (95% confidence interval [CI]).

In adjusted model the results of physical fitness tests and motor ability tests (low, medium, high), age (low, medium, high), weight (low, medium, high), body mass index (low, medium, high) and Daily step counts, steps/day, at follow-up questionnaire were entered as adjusted factors.

Figures

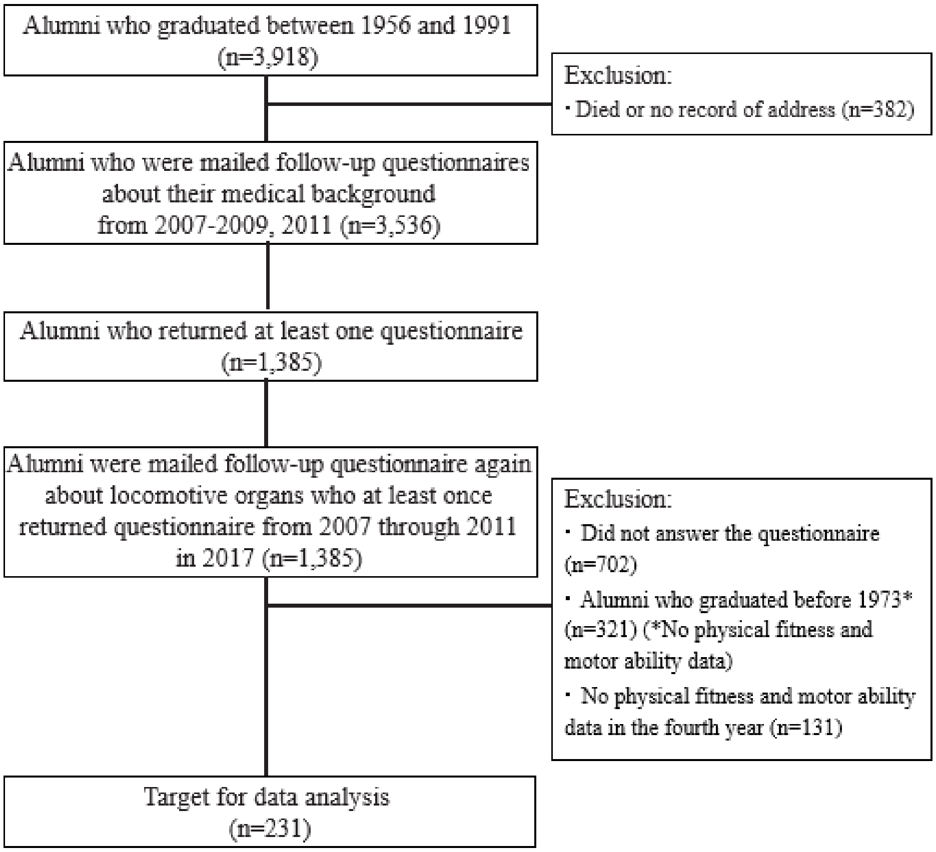

Figure 1

A flow-chart of the participants associated with the present study

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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